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Evogene - Plant genomics approach to develop enhanced food and energy sources

NASA Green Forum, September 2009



Agenda

- **Background**
- **Ag-Biotech Business**
- **Biofuels Business**
- **Summary**

*To address the growing global needs for **food, feed & energy**
by utilizing **computational** and **genomic** capabilities*

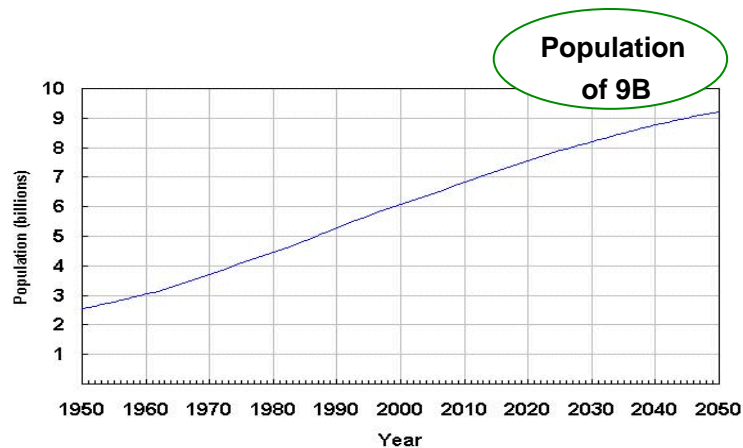


Need for Food and Feed



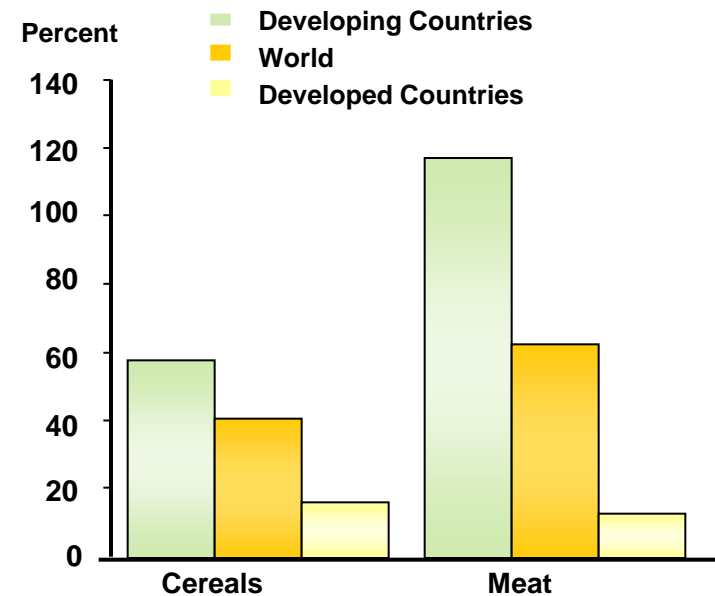
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World population growth World Population: 1950-2050



Source: U.S. Census Bureau, International Data Base, April 2005 version.

Higher demand for food and feed Increase in demand for cereals and meat: 1993-2020



Source: IFPRI IMPACT simulations

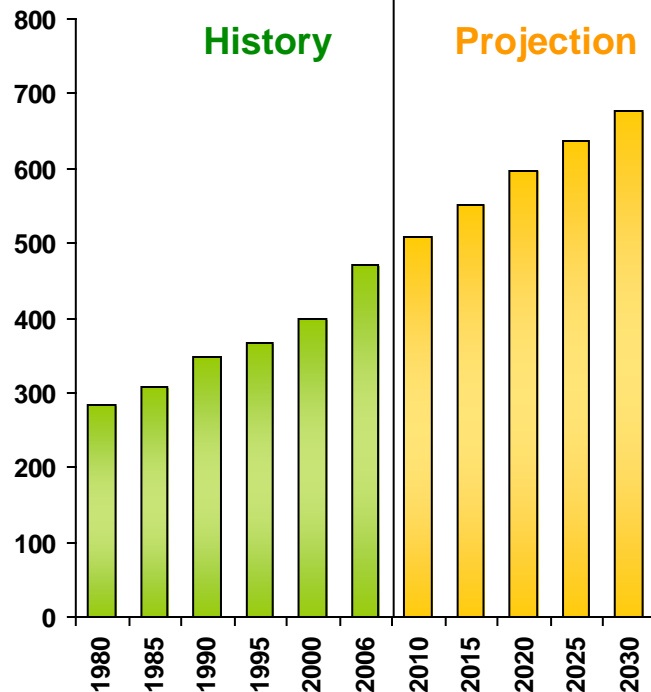
**Need to increase agricultural productivity to
maintain food & feed security**

Need For Energy



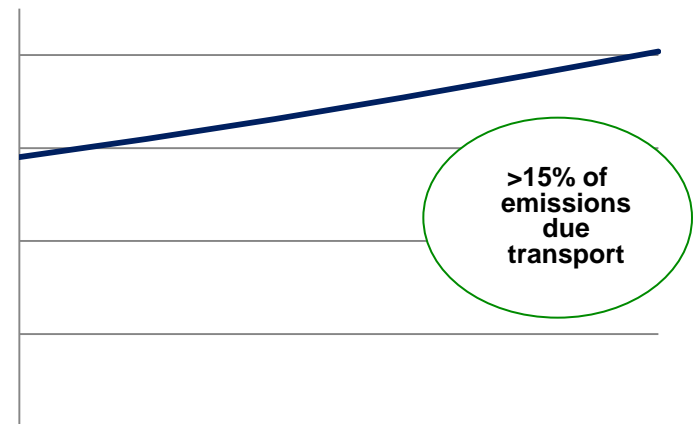
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**World Energy Consumption
Quadrillion Btu 1980-2030**



Source: EIA - International Energy Outlook, 2009

**World Energy-Related CO₂ Emissions
2006-2030, Bn Metric Tons of CO₂**



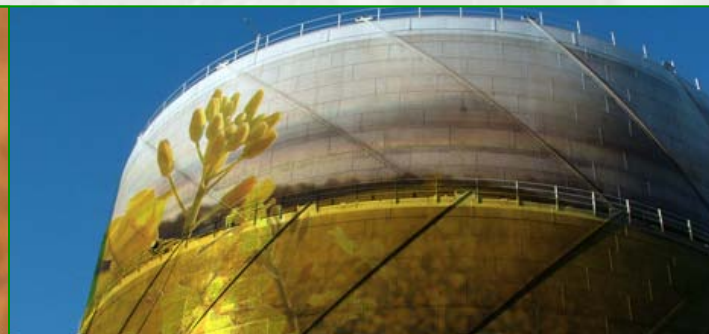
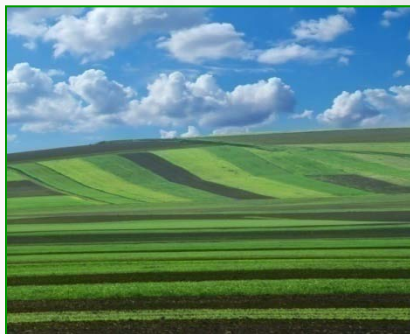
**Immediate need for sustainable & renewable
energy resources**

Evogene's Mission



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*To be the world leader in delivering **improved plants** to the
(I) **Ag-biotech** and (II) **Biofuel** industries*



Brief History



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2000

Initiated as division of Compugen (Nasdaq: CGEN)

2002

Spun-off as an independent company

2002-2009

- **Raised \$47M private investors & public**
- **June 2007 – IPO Tel Aviv Stock Exchange (EVGN)**

2007-2009

- **License agreements with Bayer, Monsanto, Pioneer/Dupont & Other**
- **Collaboration agreement with Ormat**
- **Multiyear collaboration with Monsanto, Bayer CropScience and Syngenta**

2009

- **85 Employees (mathematics, computer science, genetics, molecular biology, plant transformation and agronomy)**
- **Headquarters located in Rehovot, Israel**

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Concept: Seed + Gene = Product



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**Discovery of key genes
linked to desired plant
trait**



**In-plant validation of
key genes**



Improved Plant

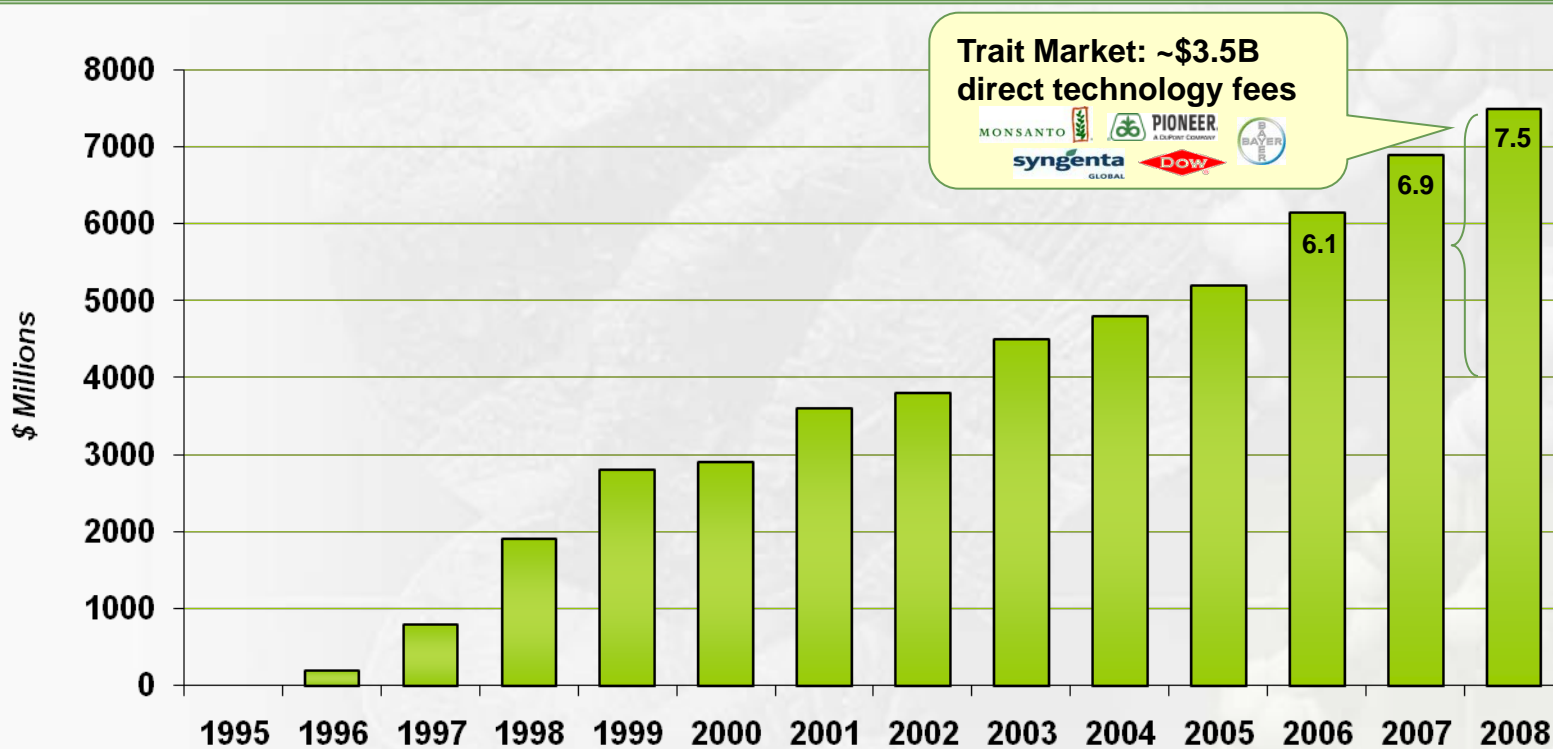


Ag-Biotech Seed Market



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Ag-Biotech Seed Market



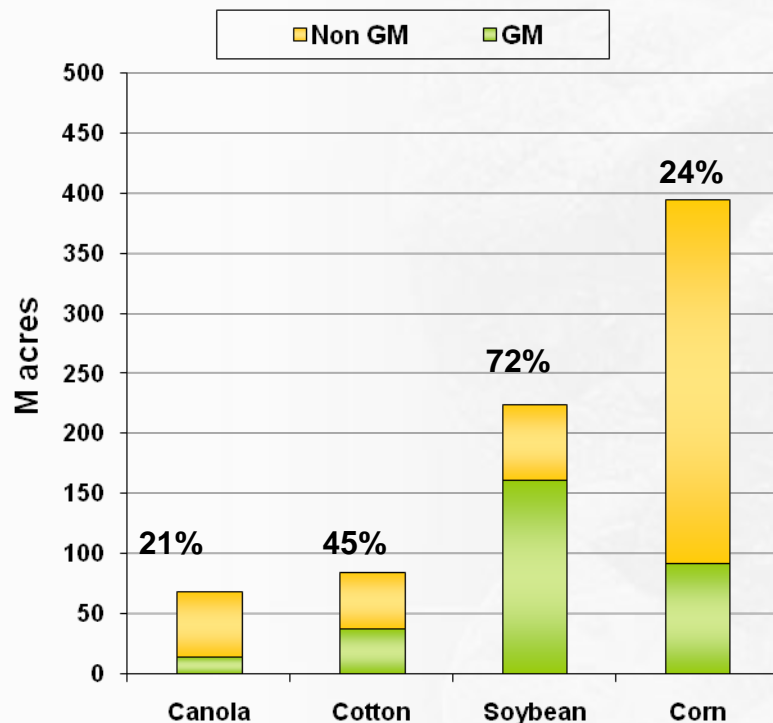
2008: Market Value - \$7.5B; 280M acres

Ag-Biotech Seed market - By Crop, 2008

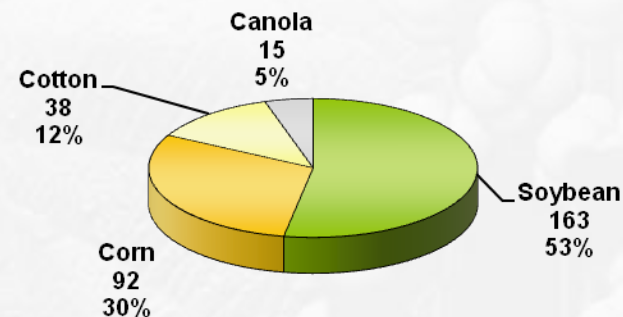


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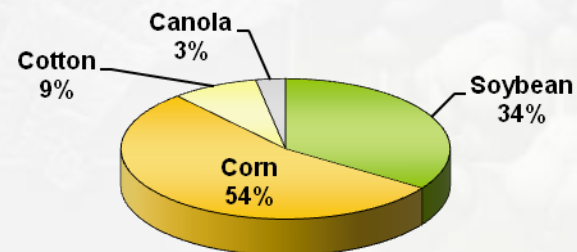
Ag-Biotech World Area Penetration By Crop 2008



Ag-Biotech area by crop (total 310M Ac)



Ag-Biotech Seed Market Value* (total \$7.5Bn)



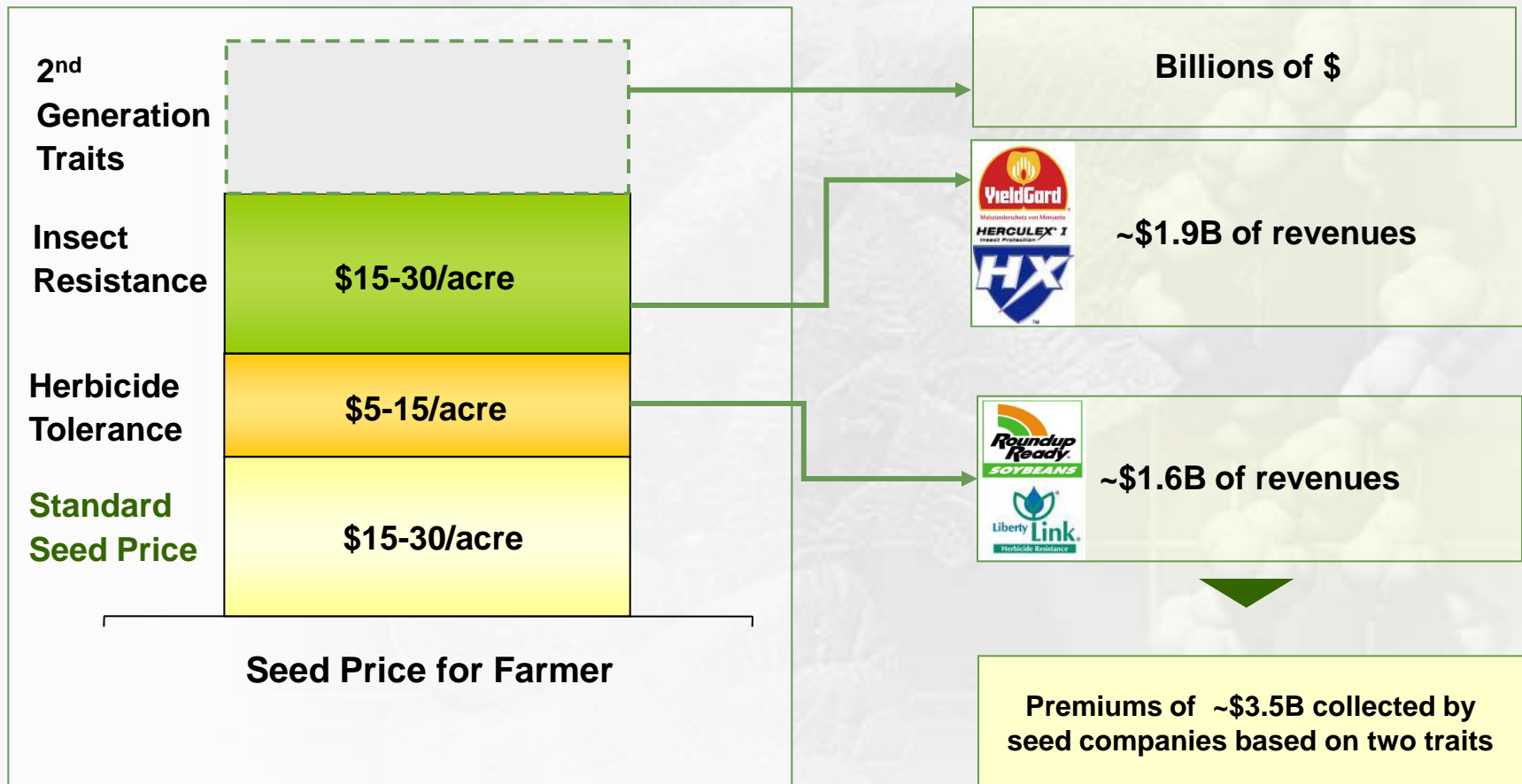
*Estimations

- Corn and Soybean - dominant Ag-Biotech crops (food, feed, biofuels)
- Expected next Ag-Biotech crops: Wheat & Rice

Generating Revenue from Traits



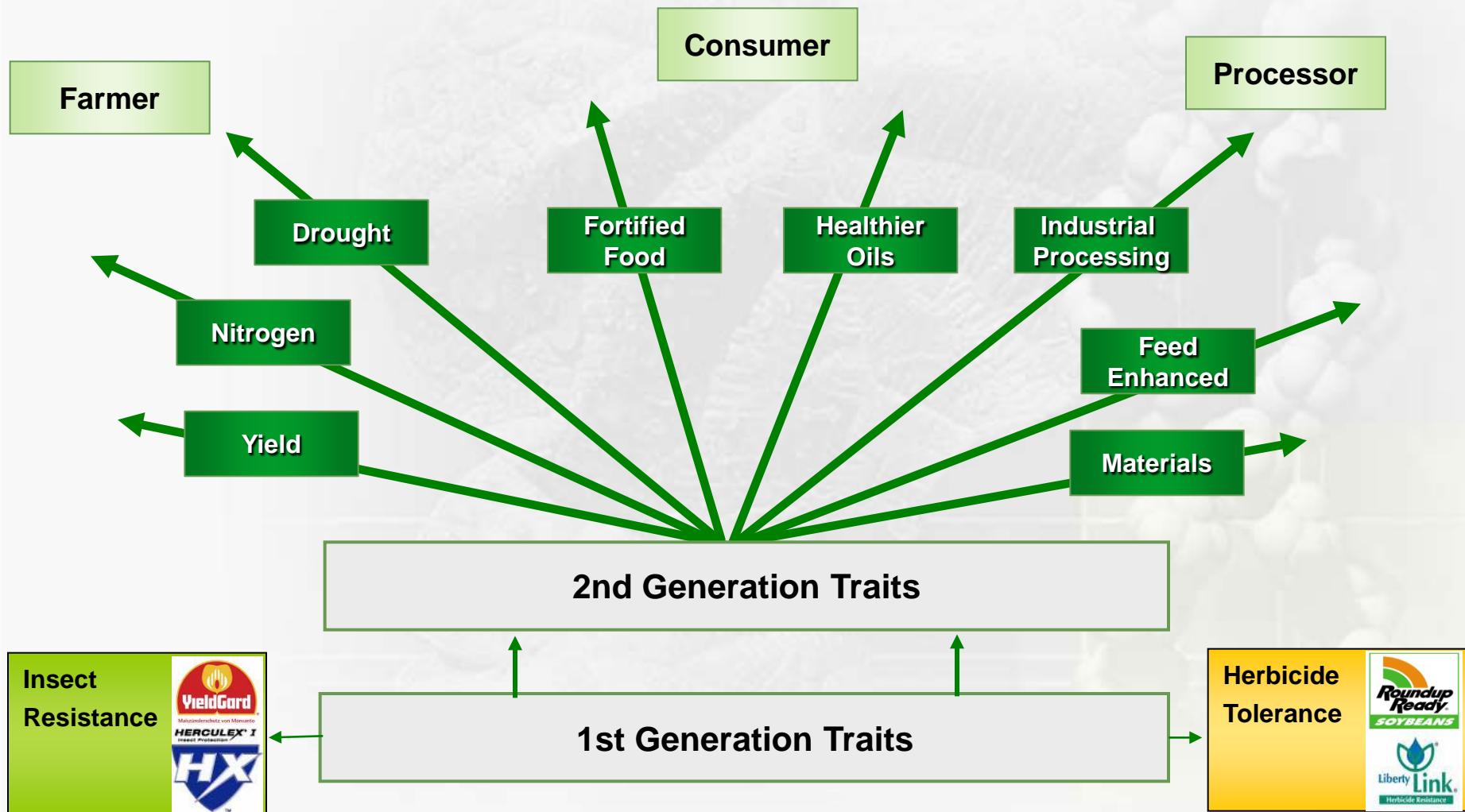
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Ag-Biotech Traits – Existing & Future Products



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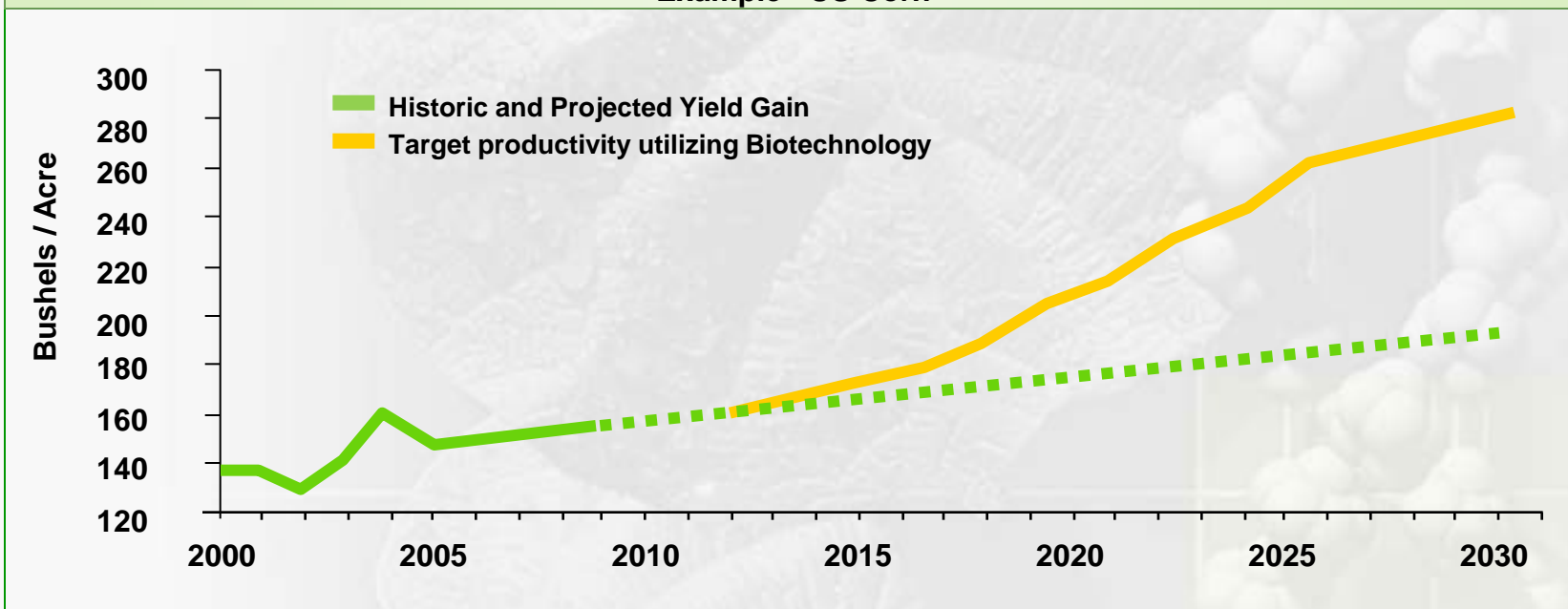
Aiming at Increasing Yield Productivity



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Utilizing technology to substantially enhance productivity

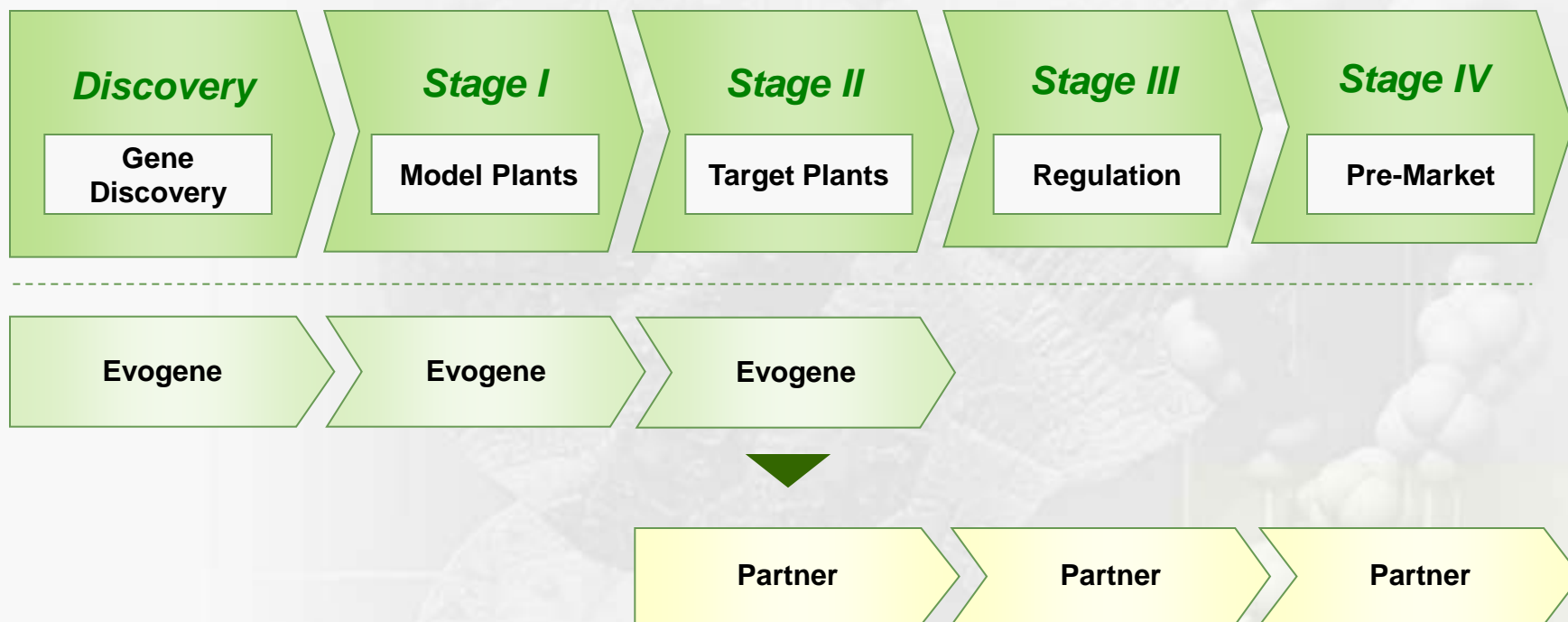
Example - US Corn



Evogene's Business Model – Ag-Biotech Business



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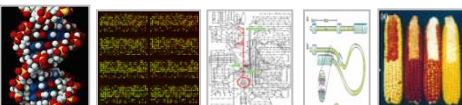


ATHLETE – Agro-Trait Harvest LEads TEchnology

Large gene pool –
more than 100 plant species



Various types of data –
from genome to phenotype

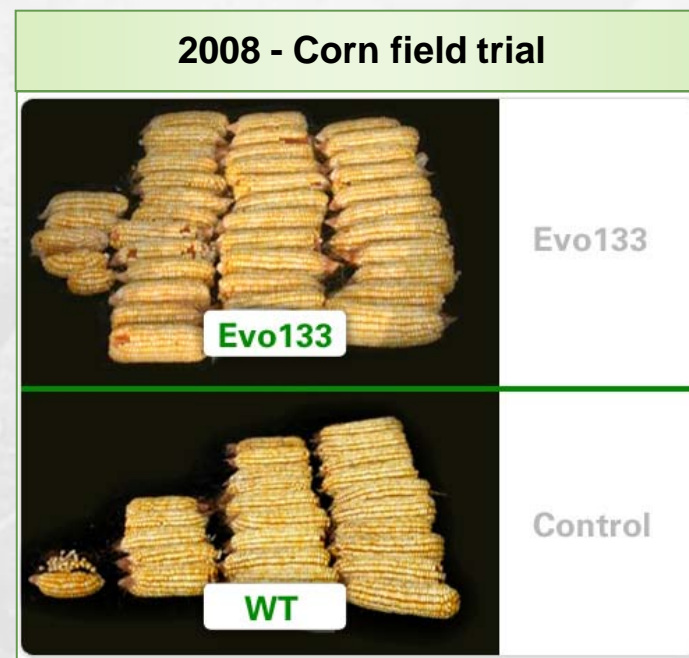
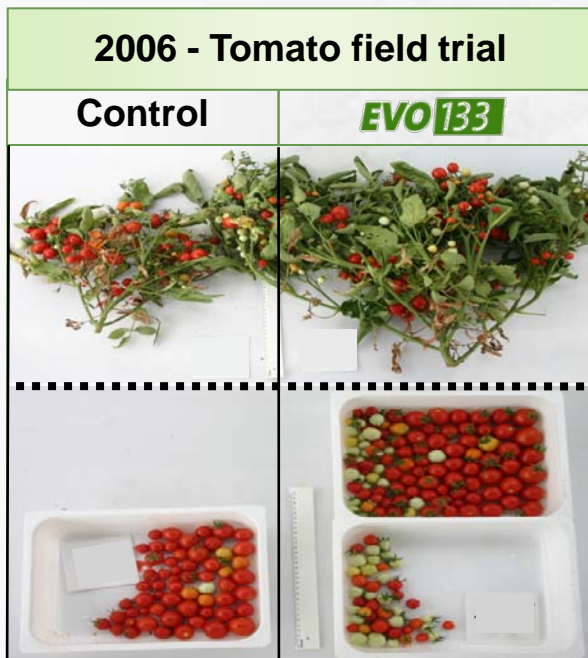


ATHLETE

100's
genes

Rapid and reliable computational discovery of candidate genes
linked to desired plant traits

Example of Results



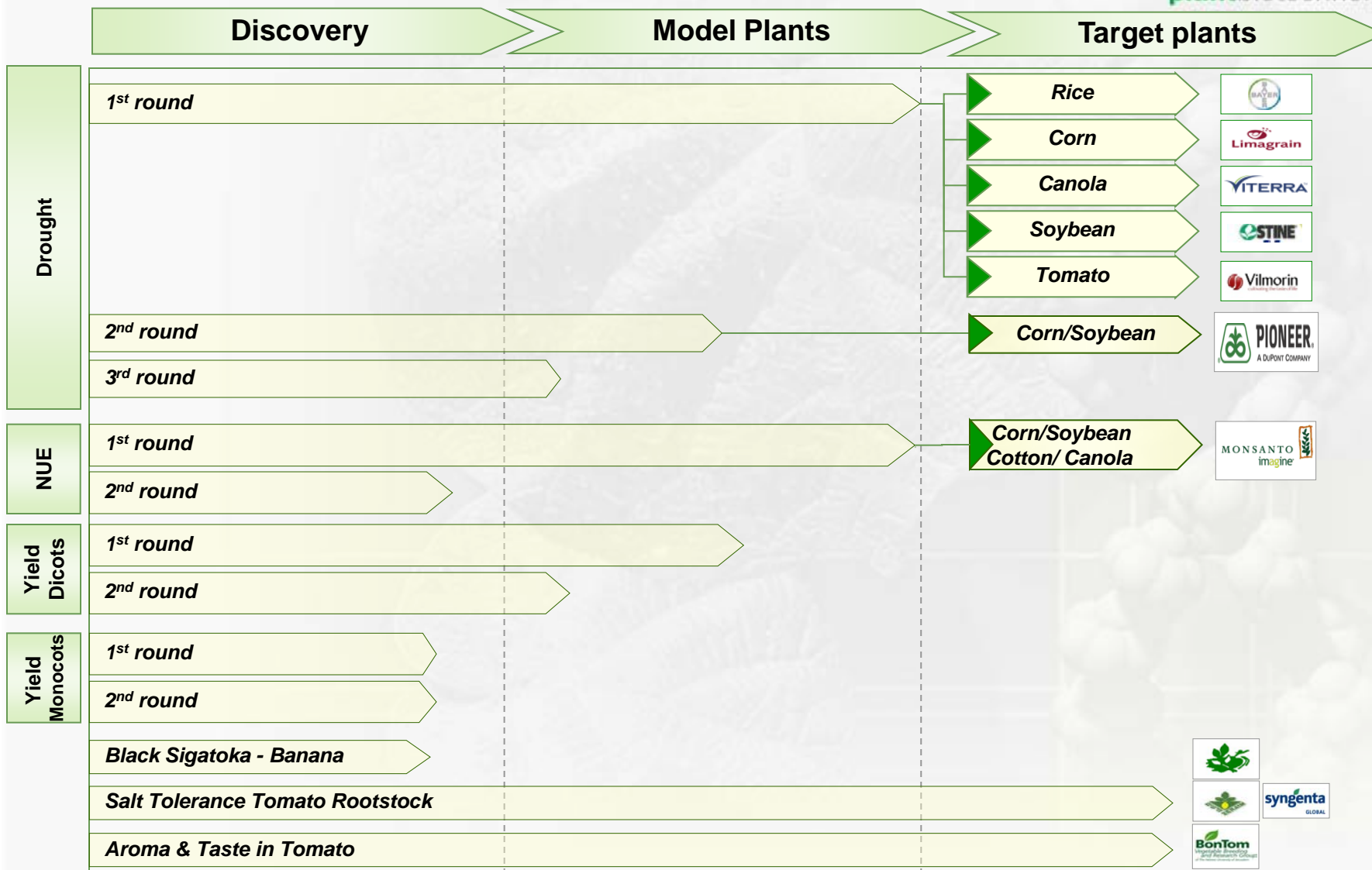
Drought Genes

- **Significantly higher yield** under normal and drought conditions
- **Successful field trial results** in Corn (2008) and Tomato (2006/7)
- On-going validation in various target plants- **Corn, Soybean, Cotton, Canola, Rice, Tomato**

Current Pipeline & Partners as of 05/2008



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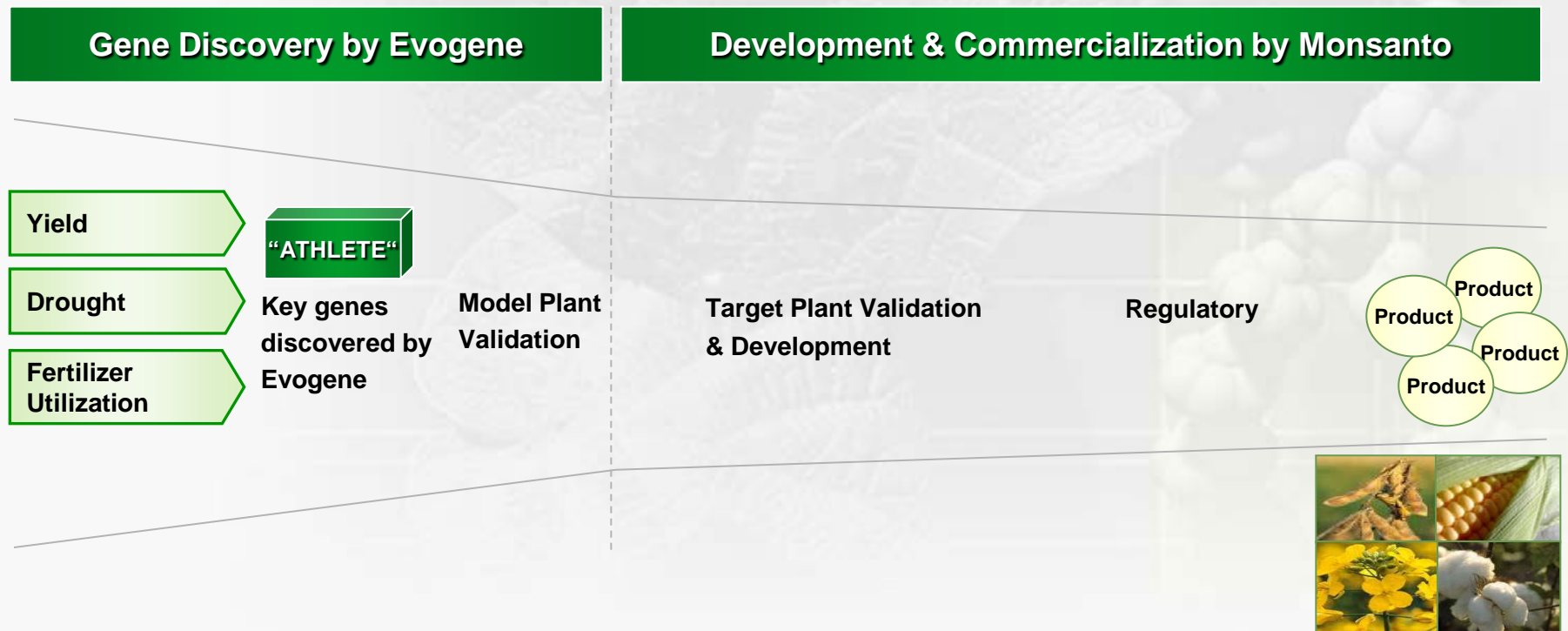


Multiyear Collaboration with Monsanto - Aug.2008



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- 5 Year Collaboration on improving **Yield, Drought Tolerance & Nitrogen Use Efficiency**
- Crops - **corn, soybean, cotton and canola**
- **\$35M** Research funding by Monsanto
- **Milestone payments + Royalties** based on sales
- Monsanto invested **\$18M equity** in Evogene (**at \$5.5 per share**) + option for additional **\$12M** subject to Evogene diligence requirements

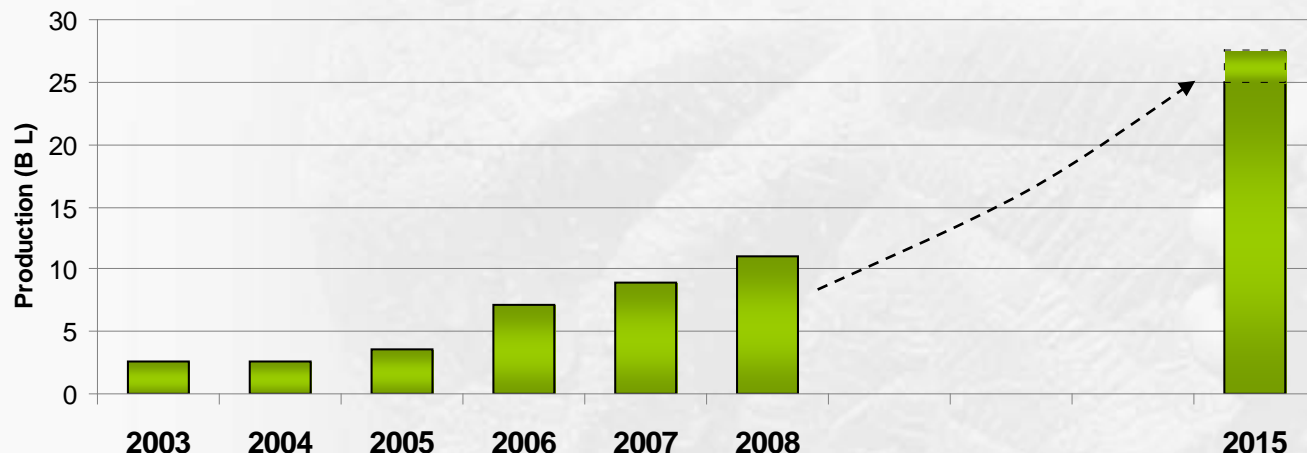


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- Summary & Future Outlook

Global Biodiesel Market is Rapidly Growing

Global Biodiesel Market - current & anticipated production



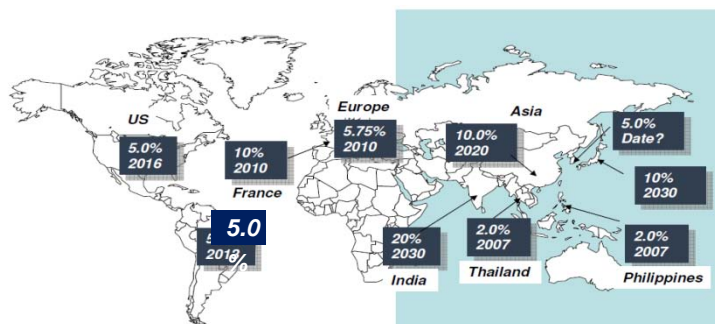
2015: expected
2.3bn L biojet →
(~1% of jet A)



Highlights

- 2008 production: 11 Bn L
- 3 top countries (Bn L):
 - Germany: 2.9 
 - USA: 2.5 
 - Brazil: 1.3 

Biodiesel growth is supported by governments – mandatory blending



Driving Biojet Market



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Motivating Forces

- Anticipated “Green Taxation” – need to reduce life cycle GHG (European Emissions Trading System)
- Fuel price and availability

Vision: Achieve carbon neutral growth and aspire to a carbon-free future through use of different alternative fuels

Biojet - main mid-term solution: Targets

- Identify viable and sustainable biofuel sources for commercial aviation
- Identify plant based feedstock
 - Lower CO₂ lifecycle
 - Not compete with food or promote deforestation

Aviation Industry Commitment to Action on Climate Change

As leaders of the aviation industry, we recognise our environmental responsibilities and agree on the need to:

- build on the strong track record of technological progress and innovation that has made our industry the safest and most efficient transport mode; and
- accelerate action to mitigate our environmental impact, especially in respect to climate change while preserving our driving role in the sustainable development of our global society.

Therefore, we, the undersigned aviation industry companies and organisations declare that we are committed to a pathway to carbon-neutral growth and aspire to a carbon-free future.

To this end, in line with the four-pillar strategy unanimously endorsed at the 2007 ICAO Assembly, we will:

1. push forward the development and implementation of new technologies, including cleaner fuels;
2. further optimise the fuel efficiency of our fleet and the way we fly aircraft and manage ground operations;
3. improve air routes, air traffic management and airport infrastructure; and
4. implement positive economic instruments to achieve greenhouse gas reductions wherever they are cost-effective.

We urge all governments to participate in these efforts by:

1. supporting and co-financing appropriate research and development in the pursuit of greener technological breakthroughs;
2. taking urgent measures to improve airspace design including civil/military allocation, air traffic management infrastructure and procedures for approving needed airport development; and
3. developing and implementing a global, scalable and stable emissions management framework for aviation through ICAO, in line with the United Nations roadmap agreed in Bali in December 2007.

Our efforts and commitment to work in partnership with governments, other industries and representatives of civil society will provide meaningful benefits on tackling climate change and other environmental challenges.

We strongly encourage others to join us in this endeavour,

Signatories include: IATA, Airbus, Boeing, Bombardier, Embraer, Rolls-Royce, Pratt & Whitney, etc.

17th Aviation & Environment Summit, 20th April 2008, Geneva, Switzerland

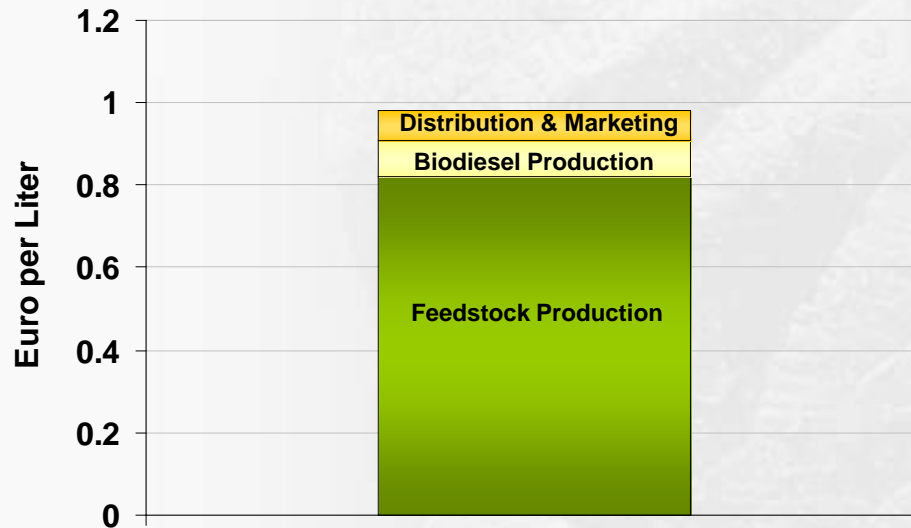
Certification process –
50/50 blend with jet-A expected to be certified by 2011 (originally planned for 2013)

Feedstock – Main Driver of Production Costs



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Biodiesel Production Costs



Soybean and Canola – main feedstock for biodiesel today



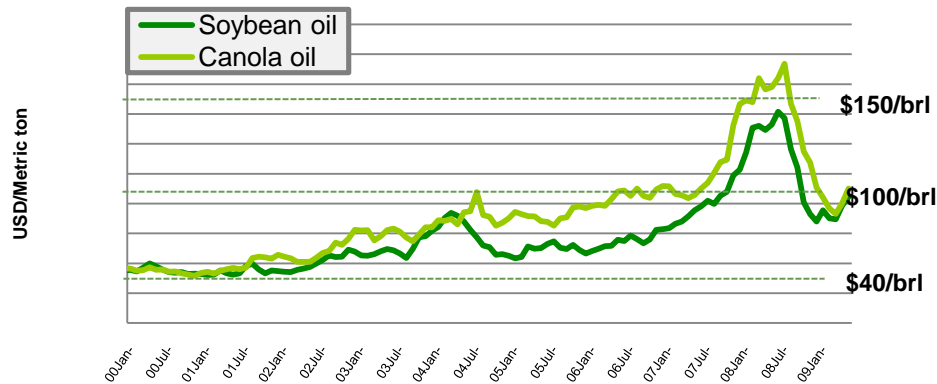
Feedstock Comprises ~80% of biodiesel production costs!

Main Bottleneck: Feedstock Sources

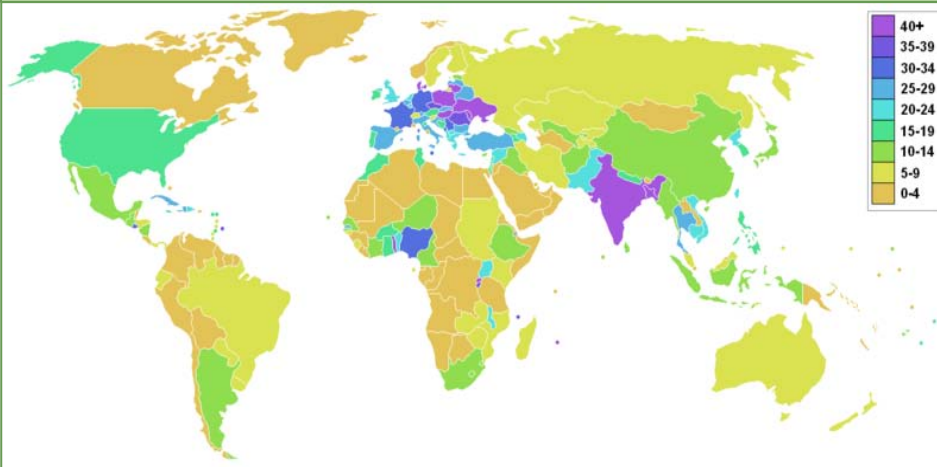


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1. Rising/volatile feedstock prices



2. Loss of arable land - 38,000 sq. miles/year







Need for 2nd generation feedstock:

- Sustainable**
 - Reduce GHG
 - Growth on non arable lands
- Available**
 - Million ha potential to meet demand
- Economic feasible**
 - Competitive cost compared to vegetables oils /fossil fuels

2nd Generation Vs. 1st generation Feedstock



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	Soy 	Canola 	Jatropha 	Castor 
Sustainability	<ul style="list-style-type: none"> ✗ Food uses ✗ Arable lands 	<ul style="list-style-type: none"> ✗ Food uses ✗ Arable lands 	<ul style="list-style-type: none"> ✓ Non edible ✓ Non arable lands 	<ul style="list-style-type: none"> ✓ Non edible ✓ Non arable lands
Availability	<ul style="list-style-type: none"> ✓ Commercial crop 	<ul style="list-style-type: none"> ✓ Commercial crop 	<ul style="list-style-type: none"> ✓ Million Ha's available land 	<ul style="list-style-type: none"> ✓ Million Ha's available land (Brazil - ~9 M Ha potential in NE; US – Millions of ha in Texas)
Economic Feasibility	<ul style="list-style-type: none"> ✗ Highly-fluctuating oil prices 	<ul style="list-style-type: none"> ✗ Highly-fluctuating oil prices 	<ul style="list-style-type: none"> ✓ High oil yield ✗ Tree - ~5 years to reach optimal yields ✗ Yield potential - unclear ✗ Handpicked (also impacts availability) ✗ Requires long time to improve by breeding 	<ul style="list-style-type: none"> ✓ High oil yield (potential of 3-5 ton/ha; ~50% oil content) ✓ Potential to turn into commercial crop → competitive oil production costs

**Main feedstock today:
not sustainable nor economical**

**2nd generation feedstock → need for
reliable supply at competitive prices**

*Utilize **technology** to develop new **2nd generation feedstock** for Biodiesel*



Castor Bean was selected as 2nd generation feedstock of focus

The Potential to Improve Castor



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Castor Today - Niche crop

- **Low yields – <1 ton/ha (~ 1 ton oil/ha)**
- **Traditional farming**
 - Insufficient seed quality
 - Low plant density
 - Handpicked
- **Limited area –1.3 million ha (~ 1 bn L of oil)**
- **Estimation - production costs over 700\$ per ton oil (equivalent \$80/brl)**
- **Very limited use as feedstock for biodiesel**



Evogene's
Technology

Future Castor – Commercial Crop

- **High yield – 4-5 ton/ha => lower production costs**
- **Modern farming**
 - Improved varieties using conventional & advanced breeding tools – drought tolerant
 - High plant density
 - Mechanical harvest
- **Potential area – millions ha**
- **Estimated production costs – 350\$ per ton oil**
- **Main feedstock for biofuel**



Castor has high potential as 2nd generation feedstock → need to improve availability and economic feasibility

Proof of Concept - Pre-Varieties in Israel



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■ Variety collection

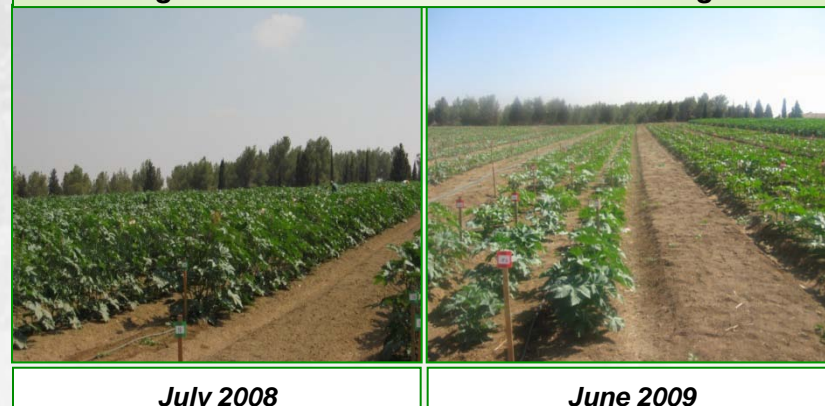
- 300 ecotypes from over 40 countries

■ Field trials in Israeli semi arid lands:

- 2008 – completion of 1st year
 - Feasibility test - potential yield of 5 tons/ha
 - Feasibility of Agro technical growth protocols – mechanical harvest demonstrated
- 2009 – 2nd year (results expected in Oct. 2009)
 - Observation field - re-trial of selected lines
 - Evaluation and selection of new castor inventories (new genetic material)
 - Agro technical tests – evaluation of seed yield under different water regimes and different plant density



Evogene's castor field trial in the Israeli Negev



Collaborators



World Leader in geothermal energy
ORMAT TECHNOLOGIES

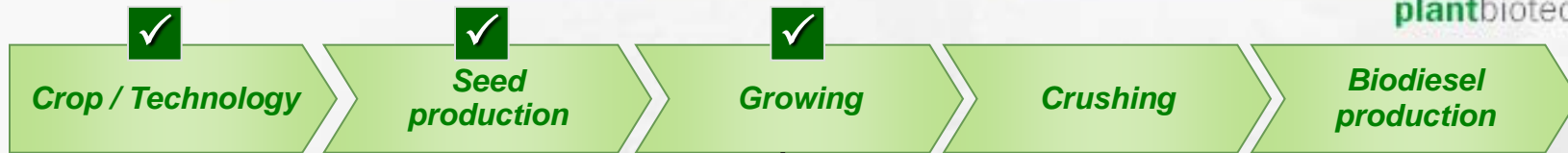
View From the Field



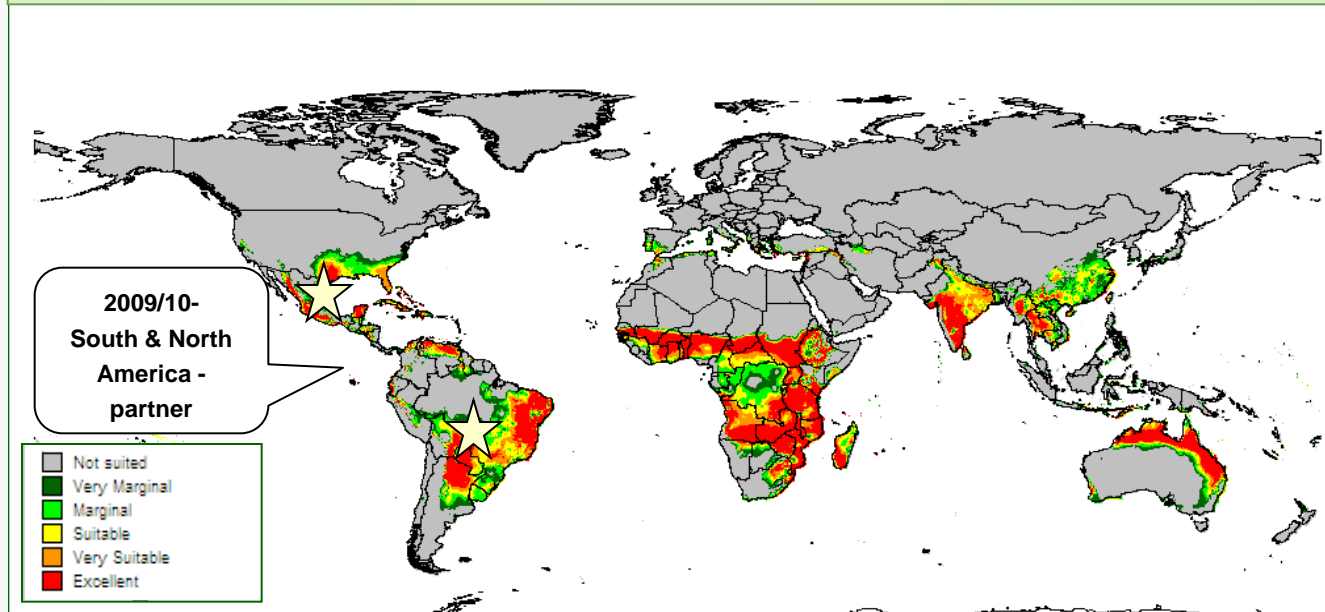
Commercialize Improved Feedstock



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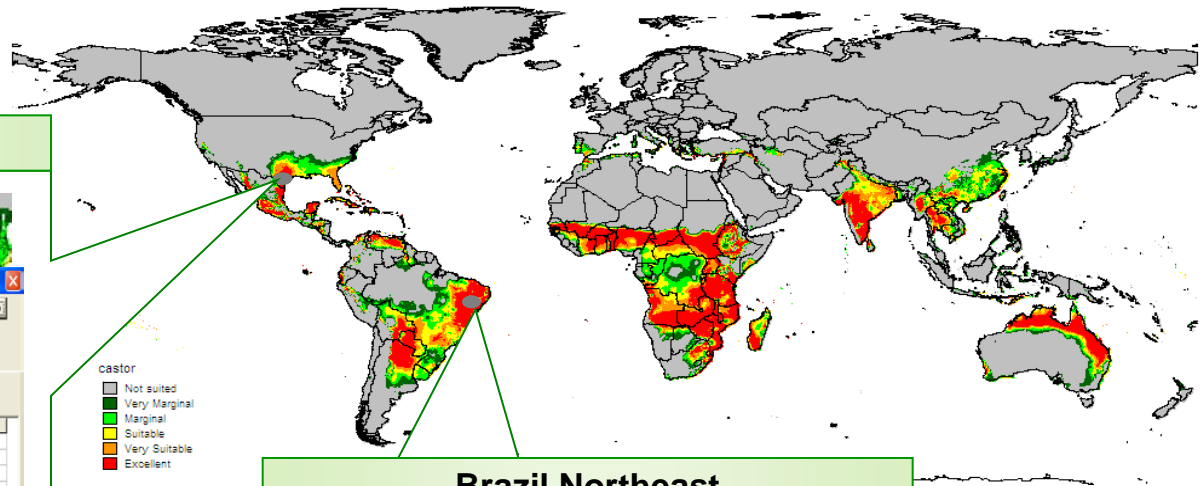
Large-scale plantation (100,000's ha)



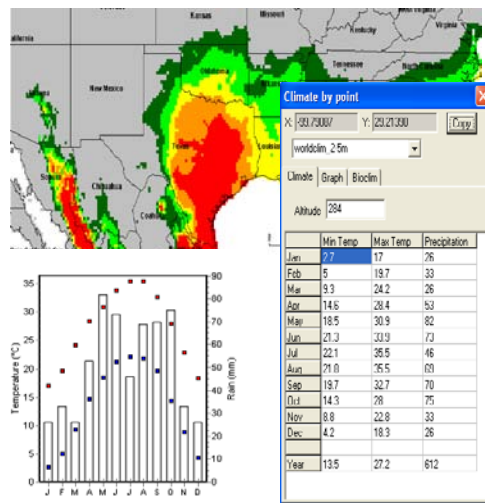
Source: GIS (Geographic Information System)

Main Target Areas – Brazil & Texas

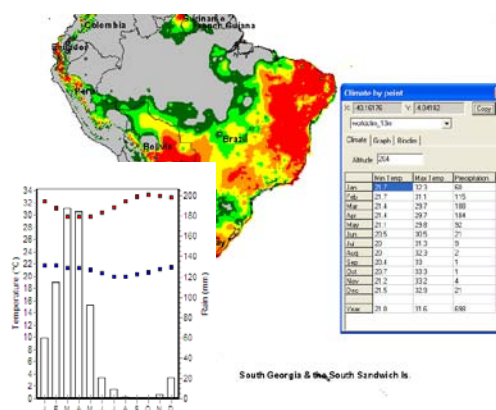
Castor potential growth areas - climate conditions suitable for castor



Texas - South



Brazil Northeast



Potential of castor as 2nd generation feedstock



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■ **Economic feasible** – potential for low cost oil => \$350 per ton

- Yield potential of 4-5 ton/ha
- ~50% oil content

■ **Sustainable**

- Non edible
- Potential for growth on non arable lands
- low water and nutrients requirements
- Complete Life Cycle Analysis is underway

■ **Available**

- Commercial scale growth - modern mechanized growth methods
- Millions of Ha in Brazil and USA

Evogene's approach:

Apply advanced breeding and modern agro-technique methods to revolutionize castor performance => from a niche crop into a high yielding modern crops

Project with NASA Glenn Research Center



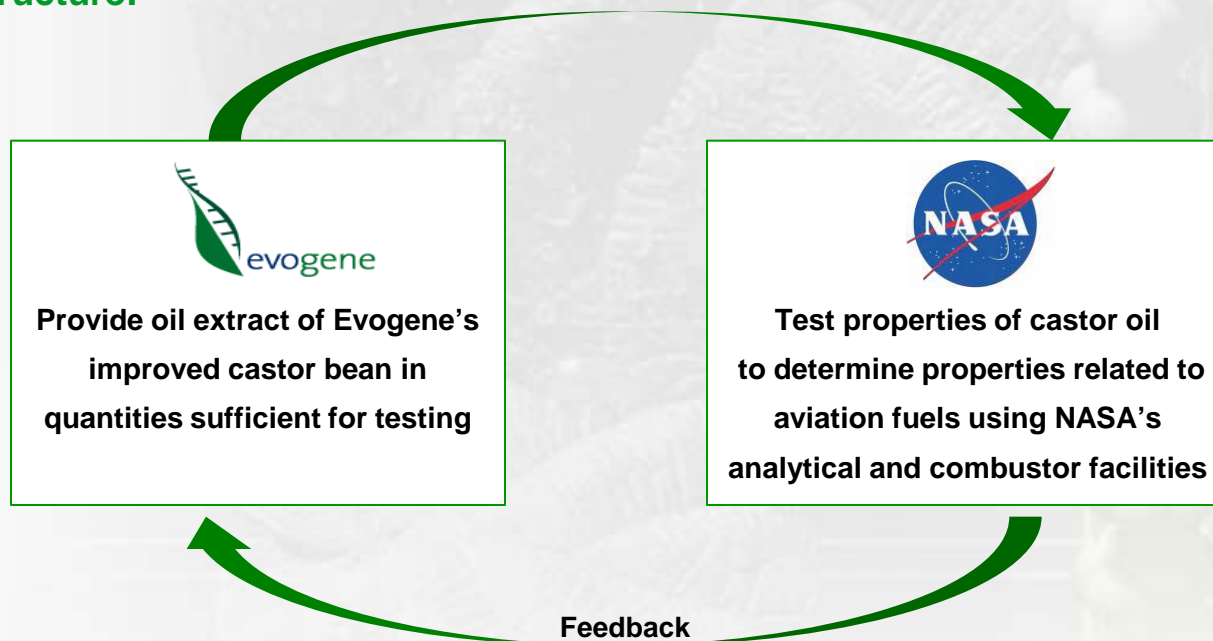
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■ Project Objective:

- Development and testing of naturally selected Evogene's castor bean oil as potential aviation fuel

■ Project Timeframe: 2.5 years (June 2009 – December 2011)

■ Project structure:





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Evogene Seminar

NASA Green Forum, September 2009

